Real-time Sensor to Monitor Suspended Sediment Loads in Streams

Chris G. Campbell
Contact: 510/495-2953, cgcampbell@lbl.gov

RESEARCH OBJECTIVES

Throughout California and worldwide, water quality is negatively impacted by suspended sediments in surface water bodies. Not only is sediment itself a major pollutant, but additional contaminants in these environments, including heavy metals and organic compounds like polychlorinated biphenyls, dioxins, and pesticides, are likely to be adsorbed to suspended sediments. Unfortunately, current methods to measure the total mass of suspended sediment mobilized in storm water runoff are inadequate. As a result, it is impossible to accurately estimate the total load of either sediment or associated contaminants transported with sediments during storms.

In response to this challenge, our project developed a fiber-optic in-stream technology (FIT) for continuous measurements of suspended sediment load in surface waterways. Our research objectives were to:

(1) Assemble and test the FIT for light absorbance measurements in suspended sediment solutions.
(2) Address calibration issues.
(3) Compare measurements to a commercially available turbidity probe.
(4) Examine portable and stationary field measurement designs.

APPROACH

The FIT is based on optical light absorbance occurring between two linear fiber-optic arrays. Suspended sediment moving between the source and detector decreases the total light intensity reaching the detector. Light in the red spectra (around 680 nm) was selected to focus on sediment particles. Commercially available turbidity probes measure light scattering at a 90º angle, which is extremely sensitive to sediment geometry (e.g., particle size and shape). The increased sampling size, linear arrangement, and uniquely paired source and detectors make the FIT a superior device for estimating sediment loads.

ACCOMPLISHMENTS

Our proof-of-concept studies examined using a low-energy light source, a red light-emitting diode (LED), connected to a linear fiber-optic array, to measure suspended sediments in a specially designed storm water simulator. Tests examined sediment loads ranging from 1 to 10 g/L, with five particle size classes from 45 to 1,000 mm. We also compared the FIT to a commercially available turbidity probe. Applications of the FIT were successful, with a high signal-to-noise ratio. By adjusting the source-detector spacing, we showed that the linear measurement range may be optimized for a 1 to 10 g/L load (Figure 1). This linear relationship allows for simple device-calibration procedures.

The turbidity probe also measured a linear response to the suspended sediment, but reached a maximum measurement at 3.0 g/L (Figure 1). This maximum may be insufficient in streams that commonly reach maximum loads of 10 g/L during large storms. The variability in turbidity measurements is also much larger than the FIT, because of turbidity's sensitivity to sediment geometry.

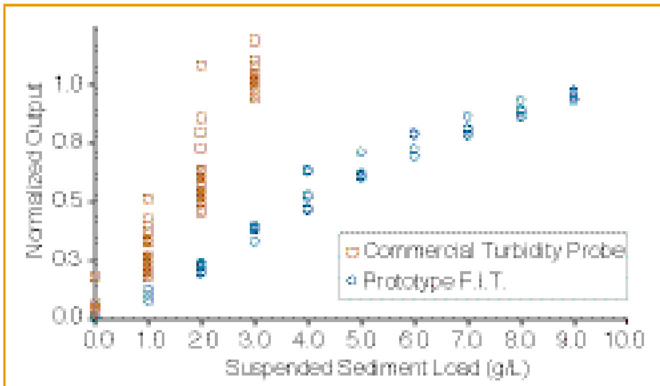

Figure 1. Measurements collected from the prototype FIT (circles) and a commercially available turbidity probe (squares) for suspended sediment loads of 1.0 to 10.0 g/L and for 5 different particle size classes. Data were collected in the laboratory using a specially designed storm water simulator. The Y-axis is the measurement value normalized between 0 and 1.

SIGNIFICANCE OF FINDINGS

The FIT is an accurate, simple to calibrate, inexpensive, and reliable alternative to turbidity measurements for real-time measurements of suspended sediment loads in streams. The application of devices like the FIT could provide information that would ultimately improve stream water quality.

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